

NOTES ON THE BIOLOGY AND ANNUAL CYCLE OF THE WOOD BORING PSOCOPTERAN *PSILOPSOCUS MIMULUS* SMITHERS (PSOCOPTERA: PSILOPSOCIDAE)

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Abstract

Preliminary information is provided on some aspects of the biology and seasonal cycle of the unusual wood boring psocopteran *Psilopsocus mimulus* Smithers on *Pinus radiata* in New South Wales.

Introduction

Unusual morphological features of the nymphs of the uncommon psocopteran *Psilopsocus mimulus* Smithers led to the suspicion that it might live within the confines of a tunnel of some kind (Smithers 1963). Not until 1993 was it confirmed as a wood borer, after a substantial population was found in Penrose State Forest, near Marulan, NSW (Smithers 1995b).

Information on the biology of Australian Psocoptera is very meagre. This note summarises preliminary observations on some aspects of the biology and seasonal cycle of *Ps. mimulus*.

Materials and methods

Observations were made at Penrose State Forest between December 1993 and May 1995, in a stand of mature *Pinus radiata* D. Don. and on specimens reared in the laboratory. Prior to this the species had been collected only occasionally in small numbers at various localities in eastern Australia (Smithers 1995b). In the laboratory, field-collected insects were kept in petri dishes lined with absorbent paper and provided with pine twigs of various thicknesses, never thicker than a few mm in diameter and about 6 cm long, into which they could bore. Water was provided on a wad of cotton wool which was kept damp but not wet enough to allow water to seep onto the paper.

Notes on the biology of *Psilopsocus mimulus*

Adult *Ps. mimulus* do not exhibit unusual morphological features but the nymphs show remarkable adaptations to life in a tunnel. These include a cylindrical body form, short legs, reduced sclerification and pigmentation of the abdominal integument, except for the hind part of the abdomen which, in contrast, is exceptionally heavily sclerotised and black, with a truncate posterior end and specialised setae, of which the tips are divided into several short, divergent branches (Smithers 1963, 1995a). The cylindrical form and colour of the heavily sclerotised hind end of the abdomen is reminiscent of wood boring beetles which block their tunnels by means of appropriately shaped elytra. *Ps. mimulus* has been recorded only on *Syncarpia glomulifera* (Smith) and *Pinus radiata*.

Adults

Food and feeding. Adults are found on the bark of the trunk, branches and twigs of the trees. They are too large to enter the tunnels in twigs in which the nymphs live. Fungal hyphae (derived from lichens or fungi on the bark surface?), fungal spores, green algae and fragments of plant detritus have been found in the gut.

Initially water was provided as droplets in the petri dishes as well as on the cotton wool pads. They drank from both sources. Rudolph (1982a, b) described and discussed the mechanism of water vapour uptake through the hypopharynx in psocopterans. In controlled experiments he recorded uptake periods of about 5-40 minutes, with varying intervals between them depending on species and conditions. During these periods the lingual sclerites are conspicuously exposed beyond the buccal cavity. Females of *Ps. mimulus* were observed extending and retracting the hypopharynx in the manner described by Rudolph and it is assumed that this was in order to absorb atmospheric moisture. The hypopharynx was exposed for periods varying from 20-60 seconds, alternating with periods of 10-15 seconds of withdrawal. The observations on *Ps. mimulus* were made under uncontrolled conditions and it is mentioned here simply to record its occurrence.

When at rest adults often adopt a posture in which the head is rested against the substratum and the abdomen raised at a wide angle to it, an unusual stance for a psocopteran.

Length of adult life. Adults in the laboratory lived 6-67 days. The longest-lived specimen was a male; the longest-lived female lived 51 days. Most specimens lived fewer than 40 days.

Mating. Mating was not observed but that it can take place soon after maturity is suggested by the fact that one female laid viable eggs only 4 days after the final nymphal moult. Prenuptial behaviour was not observed but probably does take place as this is known in many psocopterans, including the Myopsocidae (Campbell 1928), which are closely related to the Psilopsocidae (Mockford 1961).

Oviposition. Females can lay eggs as soon as 4 days after emergence and continue to do so until they are at least 11 days old. It is very likely that females produce eggs until much older as most of them lived much longer in the laboratory. This conclusion is supported by the fact that females contain only about 6 mature eggs at a time, with many more in earlier stages of development within their ovaries. Eggs are laid singly and it can be assumed that in the field the oviposition period is much longer than 11 days. When a female is about to lay she drags the end of her abdomen over the surface of the bark, sometimes probing into crevices. This may continue for a minute or more. Eventually the posterior margins of the paraprocts and the epiproct are pressed against the bark. After a brief pause an egg is quickly extruded and adheres to the bark. The egg is wet and shiny when deposited but dries

and becomes dull almost immediately. As the abdomen is withdrawn the egg is covered with a wet encrustation of faecal material which also dries almost immediately. As the end of the abdomen is raised the encrustation is moulded into a characteristic shape. The encrustation surrounds the egg and has a flat upper surface. This upper part is drawn out horizontally in one direction into a flattened plate which extends a little beyond the egg and slightly upwards as the female withdraws her abdomen. The edge of this flat extension is irregular, projecting in one or two places along its edge. The encrustation is the same colour as the bark with the result that the egg is difficult to see. Although several females were observed laying, none was seen to deposit a second egg within about half an hour. This seems to be an unusually long interval and it is possible that conditions in the petri dishes were not conducive to normal oviposition procedures and that oviposition is more frequent in the field.

Eggs

Hatching. The egg stage lasts 20-26 days. Eclosion took 24 mins from the first signs of a break in the chorion to freedom from the pronymphal cuticle.

Nymphs

Appearance. The integument of the newly hatched nymph is translucent and large bubbles can be seen moving in the gut. It takes several hours for the nymphs to colour up to the point at which the end of the abdomen is somewhat dark and sclerotised. First instar nymphs do not have the strongly sclerotised, black cylindrical form of the posterior part of the abdomen developed as extensively as in later instars. This and the form of later instars have been discussed by Smithers (1995a).

Tunnel making. First instar nymphs may initially force their way into cracks and crevices, leaving the somewhat sclerotised hind end of the abdomen exposed but soon seek out the end of a broken twig and make their own tunnels or enter and occupy an existing, vacated tunnel. They start to make a tunnel soon after their integument has hardened and attained normal colour. Older nymphs may change tunnels and nymphs of all stages will accept tunnels not of their own making. An advanced nymph made a tunnel in a twig of which the end was cracked, so some of the activity of the nymph was observed through the slit. After chewing the wood at the end of the twig to make a short entrance to the tunnel, the nymph chewed at the wall of the tunnel to widen it. It then continued chewing at the central core to extend the tunnel along the length of the twig. Chewing was almost continuous for more than an hour. There were occasional short pauses during which the only activity consisted of slight, brief contractions of the abdomen or voiding of faecal pellets. The nymph turned from time to time on its long axis, chewing different sides of the tunnel. This resulted in a smooth-sided tubular tunnel being made, a little wider than the head capsule. Tunnelling continued until the nymph was well into the tunnel before there was a longer pause in activity.

The wood removed from the wall of the tunnel is swallowed, passed through the gut and ejected as faecal pellets (Smithers 1995b). These are pale when they result from tunnel extensions, dark, almost black, when the insect is feeding. Nymphs appear always to be alone in the tunnels. On one occasion a second nymph was seen to enter an occupied tunnel. The original occupant backed up along the tunnel, causing the new arrival to retreat out of the tunnel, after which the original occupier remained with the end of its abdomen blocking the tunnel for several minutes before disappearing down the tunnel again.

Feeding and defecation. Nymphs spend most of their lives in their tunnels. They feed on the wood of the central core of the twig. They were occasionally seen on the surface of the twigs where, on one occasion, one was seen to feed on the surface of the bark. Whether *Ps. mimulus* is capable of digesting cellulose of the plant cells or subsists only on fungal growth in the tunnel is not known. The gut contains spores, pieces of fungal hyphae and remains of woody tissues. Nymphs were seen taking water from the cotton wool wad but not taking up water vapour through the hypopharynx as do the adults.

Judging by the cessation of defecation, it would appear that feeding ceases some time before ecdysis, perhaps 48 h or more. Faecal pellets are not produced during this period. Feeding starts soon after moulting. Protozoa which might be involved in aiding digestion were not found in the gut of the few specimens examined.

Remarkably large quantities of faecal material are voided by nymphs, suggesting that they feed on something of limited nutritional value or a food source in limited supply obtained from the wood, such as fungi developing on wood in the tunnel. During periods of feeding and tunnel making, the nymph backs along the tunnel to the entrance, exposes the end of the abdomen and ejects a faecal pellet (Smithers 1995b). This is a surprisingly frequent event. One recently moulted nymph produced its first faecal pellet within 24 h of moulting. In the next 24 h it produced 19 pellets and 130 faecal pellets over the next 6 days. Seven of the pellets were pale. When extending the tunnel the rate of pale faecal pellet production may be greater than usual. In one case it was as high as 3 per hour and in another occurred at intervals of 3-12 mins over a period of more than an hour, during which time 9 pellets were produced.

Moulting. The nymph leaves the tunnel prior to ecdysis, which may take place near the tunnel entrance or some distance away. It is not known how far a nymph will move from its home tunnel in the field or whether it always returns to its home tunnel. Ability to find its own tunnel again may not be important. In the laboratory nymphs did move into tunnels made by others. Full colour of the integument is regained about 2 h after ecdysis. Prior to the final nymphal moult, feeding and faecal pellet production appears to cease for several days. One nymph was seen to re-enter its own tunnel without

difficulty soon after ecdysis, despite the increased size of its head capsule, indicating that provision for the anticipated change in size must have been made by increasing tunnel diameter before the moult took place.

Instars. As the nymphs live in tunnels and survival rate was low in the laboratory, it was difficult to determine accurately the number of nymphal instars by direct observation. Fluctuation in faecal pellet numbers and size in petri dishes containing several nymphs suggest that they undergo the 6 instars usual for Psocoptera. Final instar nymphs first appeared in the field in May and the major emergence of adults was in November. Faecal pellet measurement and counts of pellet production by individuals would enable accurate data on number and length of instars to be obtained. However, improved rearing techniques are required to ensure greater survival rate of nymphs before this can be done.

Annual cycle

Ps. mimulus has one generation a year. Fig. 1 shows the seasonal occurrence of eggs, nymphs and adults. The figure gives the appearance of several weeks delay between emergence of the first adults and commencement of oviposition. This is probably not so. Eggs are very difficult to find in the field as they are well camouflaged and laid singly. Although a few adults (recorded in Fig. 1) may be present in the field from the middle of September, the adult population is clearly at its peak in November and December, suddenly declining in early January. It can be inferred that there are certainly some eggs in the field by the end of September as females emerging later in the laboratory were capable of laying eggs within a few days. In Fig. 1, the first recorded eggs, laid during the week of 18 November, are those associated with a sudden major November emergence of adults. As adults emerge over a fairly long period, are long-lived and clearly lay over a long period, small nymphs occur when nymphs which have hatched earlier in the season are already in a later instar, as is the situation in January.

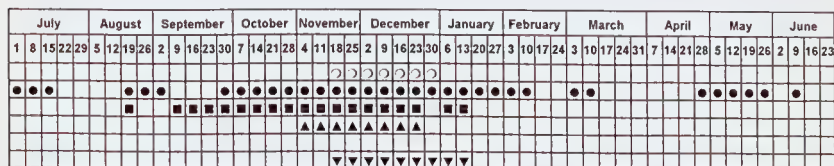


Fig. 1. Seasonal cycle of *Psilopsocus mimulus* on *Pinus radiata*. Laboratory and field records from Penrose State Forest combined on a weekly basis from December 1993 to May 1995. ○ = eggs; ● = nymphs; ■ = adults; ▲ = peak period for adults; ▼ = *Corticaria japonica* beetles.

Natural enemies and associates in the tunnels

One species of chalcidoid parasite, not yet identified, is the only natural enemy so far definitely associated with *Ps. mimulus*. It was found attacking nymphs in the tunnels and itself pupating there in a silken cocoon. Some dead nymphs were found covered in a white fungus but it is not yet known if this is a parasitic fungus or a saprophyte associated with dead nymphs.

A small beetle, *Corticaria japonica* Reitter (Lathridiidae), occurs in empty tunnels of *Ps. mimulus*, sometimes several in one tunnel, from mid November to January. It has not yet been seen in a tunnel with a nymph nor has it been seen attempting to enter an occupied tunnel. *C. japonica* is recorded feeding on fungal spores.

The unusual nymphal habitat of *Ps. mimulus* and its wood boring and feeding habit suggest that detailed study and comparison with the biology of other wood boring insects would be interesting.

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